# REPORT DOCUMENTATION PAGE

| | |
|---|---|
| 1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED | 1b. RESTRICTIVE MARKINGS |
| 2a. SECURITY CLASSIFICATION AUTHORITY | 3. DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited |
| 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE | |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S) | 5. MONITORING ORGANIZATION REPORT NUMBER(S): CR 89-06 |
| 6a. NAME OF PERFORMING ORGANIZATION: Science Applications International Corporation; 6b. OFFICE SYMBOL (*If applicable*) | 7a. NAME OF MONITORING ORGANIZATION: Naval Environmental Prediction Research Facility |
| 6c. ADDRESS (*City, State, and ZIP Code*): Monterey, CA 93940 | 7b. ADDRESS (*City, State, and ZIP Code*): Monterey, CA 93943-5006 |
| 8a. NAME OF FUNDING / SPONSORING ORGANIZATION: Commander, Naval Oceanography Command; 8b. OFFICE SYMBOL (*If applicable*) | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: N00014-88-D-0510 |
| 8c. ADDRESS (*City, State, and ZIP Code*): J.C. Stennis Space Center, MS 39529-5000 | 10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO. |

11. TITLE (*Include Security Classification*)

Severe Weather Guide - Mediterranean Ports - 27. Genoa (U)

12. PERSONAL AUTHOR(S)

Englebretson, Ronald E.

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REPORT (*Year, Month, Day*) | 15. PAGE COUNT |
|---|---|---|---|
| Final | FROM 9/15/88 TO 4/15/89 | 1989, June | 50 |

16. SUPPLEMENTARY NOTATION

Funding source: O&M,N-1

| 17 COSATI CODES | | |
|---|---|---|
| FIELD | GROUP | SUB-GROUP |
| 04 | 02 | |
| | | |

18. SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)

Storm haven; Mediterranean meteorology; Genoa port; Mediterranean oceanography

19. ABSTRACT (*Continue on reverse if necessary and identify by block number*)

This handbook for the port of Genoa, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

| | |
|---|---|
| 20. DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS | 21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL: Dennis C. Perryman, contract monitor | 22b. TELEPHONE (*Include Area Code*): (408) 647-4709; 22c. OFFICE SYMBOL: O&M,N-1 |

AN (1) AD-A211 211
FG (2) 040200
FG (2) 080300
CI (3) (U)
CA (5) SCIENCE APPLICATIONS INTERNATIONAL CORP MONTEREY CA
TI (6) Severe Weather Guide - Mediterranean Ports - 27. Genoa.
TC (8) (U)
DN (9) Final rept. 15 Sep 88-15 Apr 89,
AU (10) Englebretson, Ronald E.
RD (11) Jun 1989
PG (12) 58
CT (15) N00014-88-D-0510
RN (18) NEPRF-CR-89-06
RC (20) Unclassified report
DE (23) *MARINE METEOROLOGY, *PORTS, (FACILITIES), *STORMS, DECISION MAKING, EVASION, HANDBOOKS, HARBORS, HAZARDS, ITALY, LIMITATIONS, MEDITERRANEAN SEA, OCEANOGRAPHIC DATA, SEA STATES, SHIPS, THUNDERSTORMS, VISIBILITY, WIND.
DC (24) (U)
ID (25) Genoa(Italy), Storm havens.
IC (26) (U)
AB (27) This handbook for the port of Genoa, one in a series of severe weatner guides for Mediterranean ports, provides decision-making guidance for snip captains whose vessels are tnreatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captains's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information. Keywords: Italy ports facilities; Sea states; Marine meteorology; Mediterranean Sea harbors; Storm havens; Mediterranean Sea meteorology. (edc)
AC (28) (U)
DL (33) 01
SE (34) F
CC (35) 417277

#

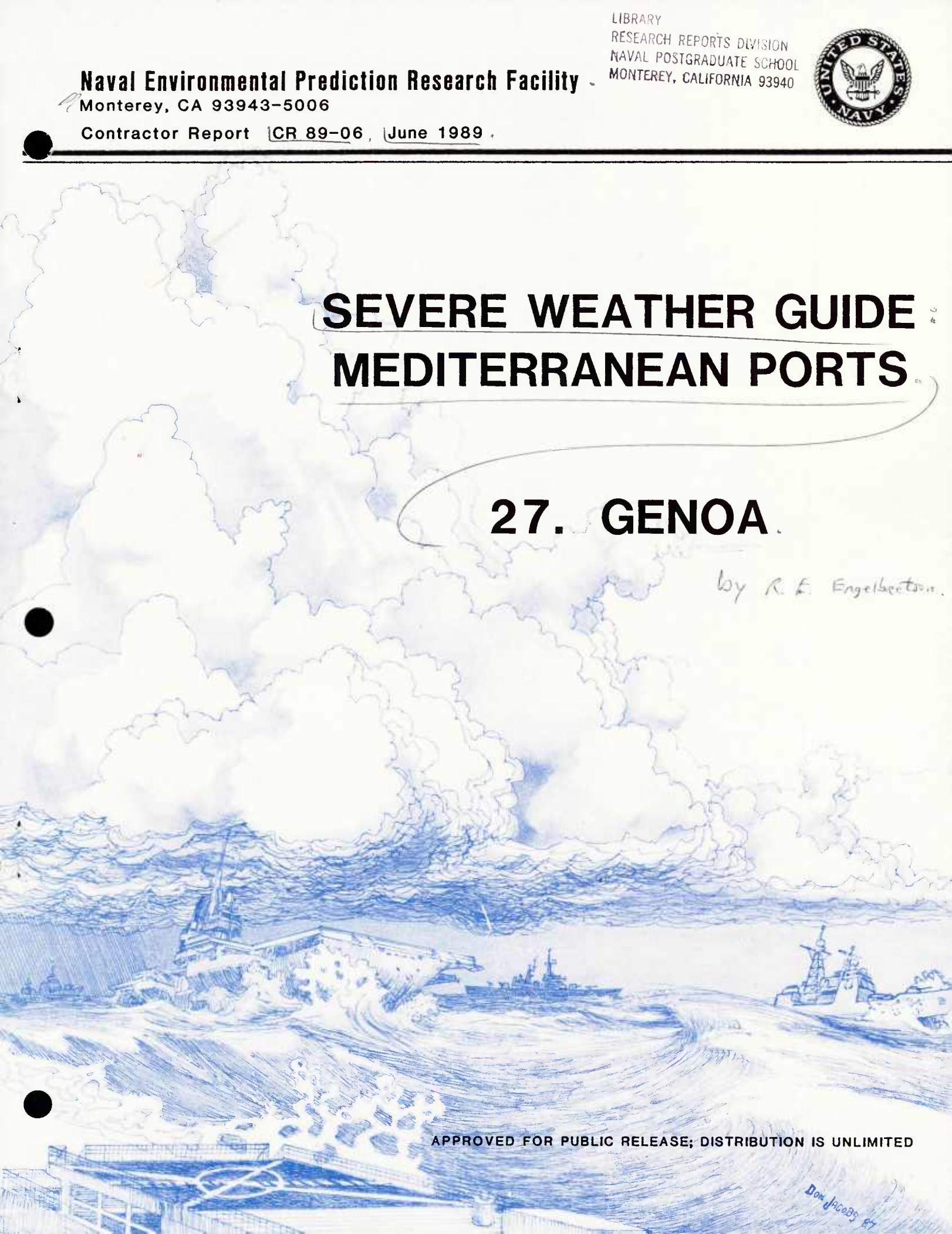
**Naval Environmental Prediction Research Facility**
Monterey, CA 93943-5006

Contractor Report CR 89-06, June 1989

# SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

## 27. GENOA

by R. E. Engelbertson





Don Jacobs 87

CONTENTS

# FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Naval Environmental Prediction Research Facility to create products for direct application to Fleet operations. The research was conducted in response to Commander Naval Oceanography Command (COMNAVOCEANCOM) requirements validated by the Chief of Naval Operations (OP-096).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to Naval Oceanography Command Center (NAVOCEANCOMCEN), Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to the Naval Environmental Prediction Research Facility for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

W. L. SHUTT
Commander, U.S. Navy

# PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review.

| 1988 NO. | PORT |
|---|---|
| 1 | GAETA, ITALY |
| 2 | NAPLES, ITALY |
| 3 | CATANIA, ITALY |
| 4 | AUGUSTA BAY, ITALY |
| 5 | CAGLIARI, ITALY |
| 6 | LA MADDALENA, ITALY |
| 7 | MARSEILLE, FRANCE |
| 8 | TOULON, FRANCE |
| 9 | VILLEFRANCHE, FRANCE |
| 10 | MALAGA, SPAIN |
| 11 | NICE, FRANCE |
| 12 | CANNES, FRANCE |
| 13 | MONACO |
| 14 | ASHDOD, ISRAEL |
| 15 | HAIFA, ISRAEL |
| 16 | BARCELONA, SPAIN |
| 17 | PALMA, SPAIN |
| 18 | IBIZA, SPAIN |
| 19 | POLLENSA BAY, SPAIN |
| 20 | LIVORNO, ITALY |
| 21 | LA SPEZIA, ITALY |
| 22 | VENICE, ITALY |
| 23 | TRIESTE, ITALY |
| 24 | CARTAGENA, SPAIN |
| 25 | VALENCIA, SPAIN |

| 1989 | PORT |
|---|---|
| 26 | SAN REMO, ITALY |
| 27 | GENOA, ITALY |
| 28 | PORTO TORRES, ITALY |
| 29 | PALERMO, ITALY |
| 30 | MESSINA, ITALY |
| 31 | TAORMINA, ITALY |
| | BENIDORM, SPAIN |

| 1990 | PORT |
|---|---|
| | TARANTO, ITALY |
| | ALEXANDRIA, EGYPT |
| | PORT SAID, EGYPT |
| | ANTALYA, TURKEY |
| | ISKENDERUN, TURKEY |
| | IZMIR, TURKEY |
| | GOLCUK, TURKEY |
| | ISTANBUL, TURKEY |

| 1991 | PORT |
|---|---|
| | ROTA, SPAIN |
| | TANGIER, MOROCCO |
| | ALGIERS, ALGERIA |
| | TUNIS, TUNISIA |
| | BIZERTE, TUNISIA |
| | SFAX, TUNISIA |
| | VALETTA, MALTA |

| 1992 | PORT |
|---|---|
| | SOUDA BAY, CRETE |
| | PIRAEUS, GREECE |
| | KALAMATA, GREECE |
| | THESSALONIKI, GREECE |
| | CORFU, GREECE |
| | KITHIRA, GREECE |
| | LARNACA, CYPRUS |
| | DUBROVNIK, YUGOSLAVIA |
| | SPLIT, YUGOSLAVIA |
| | GULF OF SOLLUM |

# PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

RECORD OF CHANGES

| CHANGE NUMBER | DATE OF CHANGE | DATE ENTERED | PAGE NUMBER | ENTERED BY |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

# 1. GENERAL GUIDANCE

## 1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

### 1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

### 1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.
B. Cruise reports were reviewed.
C. Navy personnel with current or previous area experience were interviewed.
D. A preliminary report was developed which included questions on various local conditions in specific harbors.
E. Port/harbor visits were made by NEPRF personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained.
F. The cumulative information was reviewed, combined, and condensed for harbor studies.

### 1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,
B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,
C. local wind wave conditions, and
D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

## 1.2 CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested precautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

# 2. CAPTAIN'S SUMMARY

The Port of Genoa, the leading seaport and principal ship repair center of Italy, is located on the coast of northwest Italy at approximately 44°25'N 8°57'E (Figure 2-1). It is on the extreme northern shore of the Ligurian Sea, about 230 n mi northwest of Gaeta.

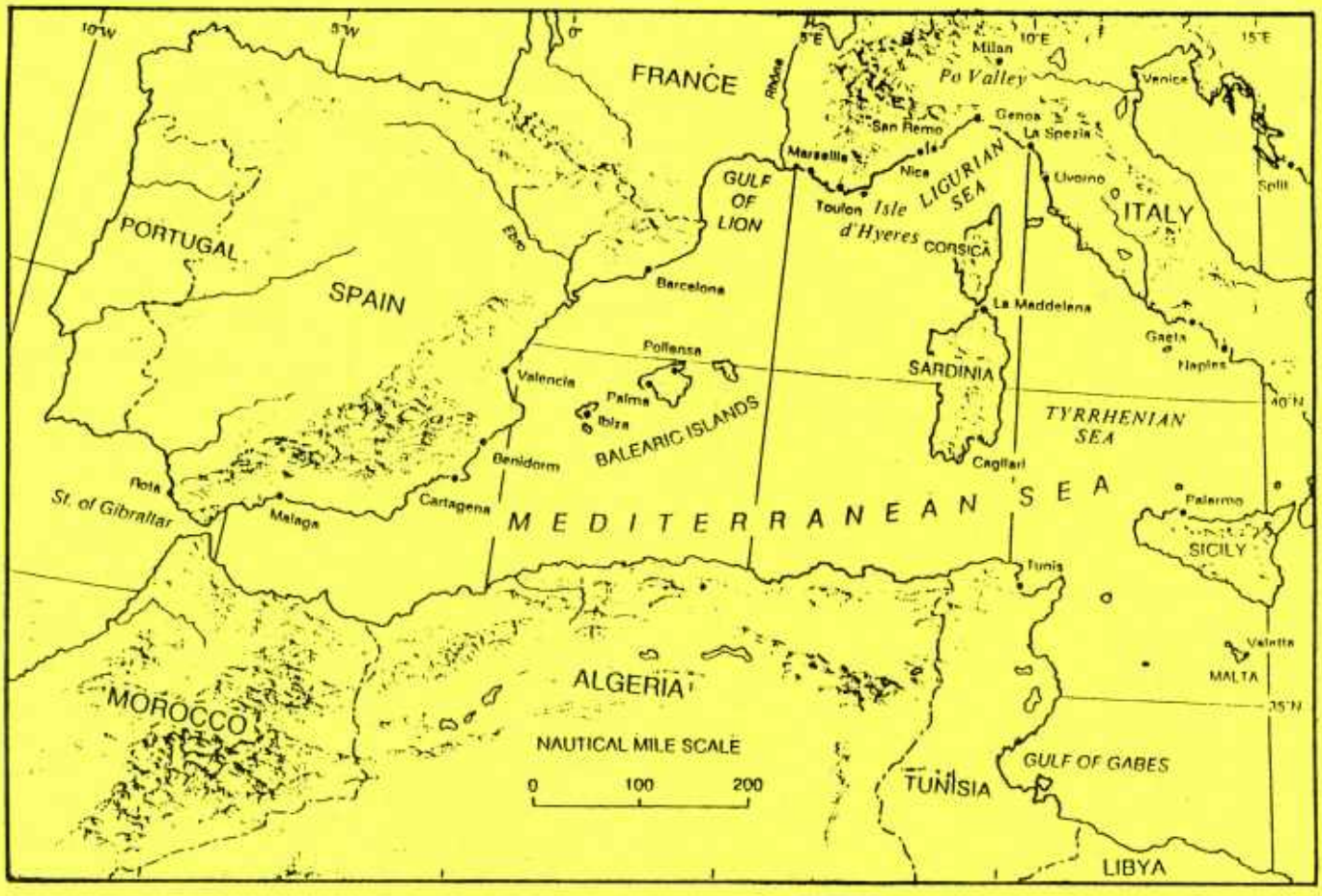



Figure 2-1. Western Mediterranean Sea.

The Port is situated near the northern most part of the Gulf of Genoa (Figure 2-2) at the foot of a range of 2500-3000 ft coastal mountains (Hydrographer of the Navy, 1965). The city of Genoa is located about 43 n mi west-northwest of La Spezia, or about 80 n mi northeast of Nice. The northern most point of the Island of Corsica lies 86 n mi to the south of the Port.

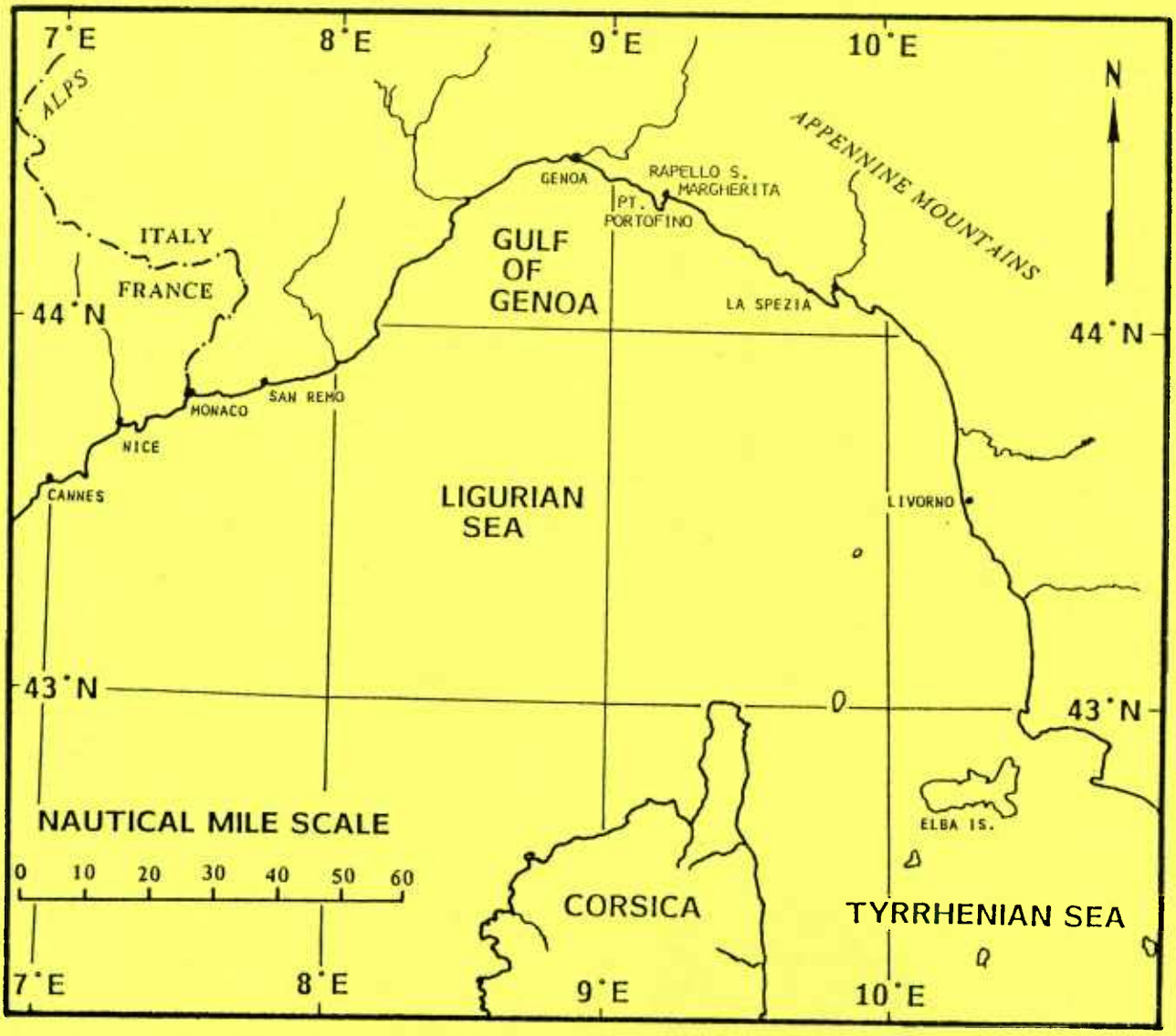



Figure 2-2. Northwest Coast of Italy and Gulf of Genoa Area.

The Port of Genoa is protected to seaward (south) by a long detached two-part mole/breakwater (Figure 2-3). The western part is called Diga (breakwater) Foranea and the eastern Molo (mole) Duca Galliera. The western boundary of the Port is formed by Molo Nino Ronco. The principal entrance, the east entrance, is over 2100 ft wide. It is located between the eastern end of Molo Duca Galliera and a near shore breakwater. Use of the western entrance, located between Molo Nino Ronco and the head of Diga Foranea is restricted. Inside the outer mole/breakwater the harbor consists of Avamporto (outer harbor) and Bacino (basin) delle Grazie and Porto (port) Vecchio in the inner harbor to the north and Bacino della Lanterna and Baccino di Sampierdarena to the west. Both of these western portions are bounded on the south (seaward) by the main detached mole/breakwater.

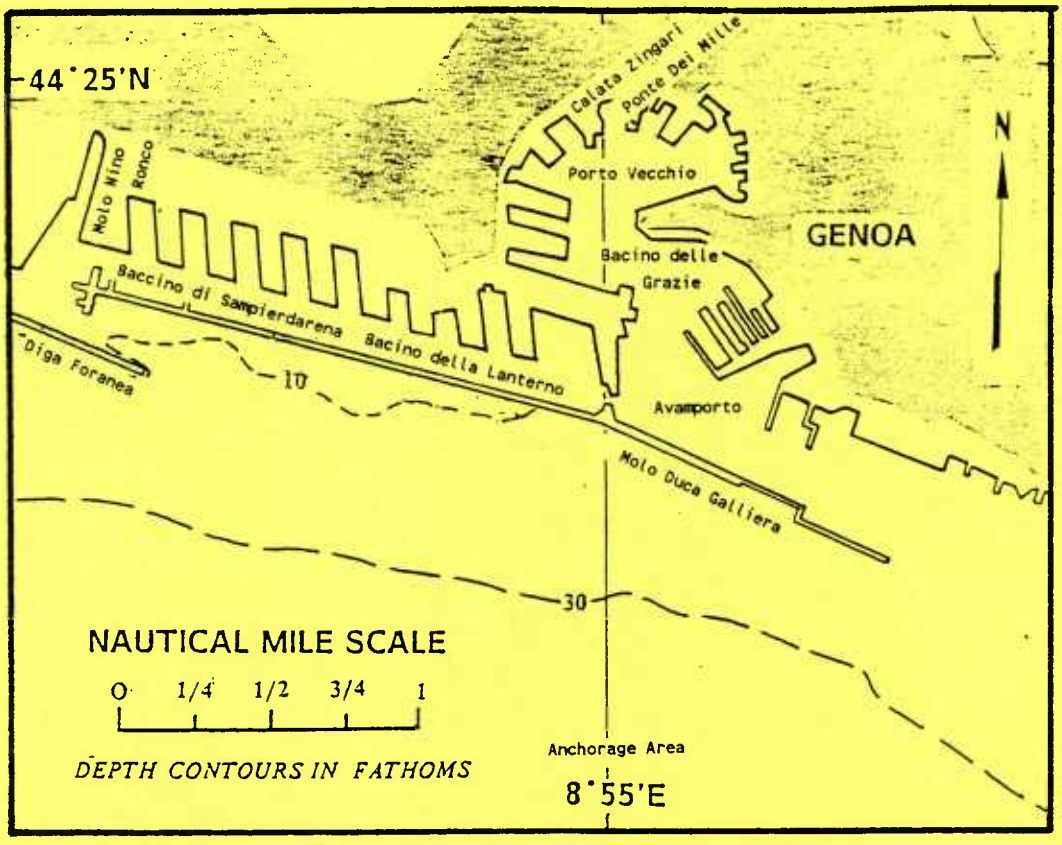



Figure 2-3. Port of Genoa.

The Primary berth is the quay wall at Calata Zingari, adjacent to the Maritime Station (FICEURLANT, 1987). Naval ships normally mediterranean moor, because the pier side berths are usually being used by passenger ships. Berthing on the inside of Molo Duca Galliera is not preferred due to the lack of fenders, bumpers, camels, etc. and the occurrence of surging due to any one of the following factors: (1) Seas or swell from the east-southeast to south-southwest, (2) small barometric pressure fluctuations, and (3) frequent large ship traffic. These surges cause little vertical movement but will generate significant horizontal movement which poses potential damage to a moored ship.

The primary anchorage is one (1) n mi south of the breakwater (see Figure 2-3). The fleet landing is located at Ponte Dei Mille, adjacent to Calata Zingari. The anchorage depths are 25 fathoms or more with a mud bottom which provided good holding. However, at least one case of a tanker dragging a single anchor and wrecking on the breakwater has occurred in recent years during strong southwesterly wind/swell conditions. A second anchorage area is located about 15 n mi southeast of Genoa in a small gulf between the mainland and Point Portofino. The fleet landing for this anchorage is at Rapello Santa Marghetia.

Both tides and currents are negligible in the harbor. Outside the harbor an east to west current of 1.0 to 1.5 kt exists. This current increases in speed during strong southeasterly wind conditions.

Specific hazardous conditions, vessel conditions, and suggested precautionary/evasion action scenarios are summarized in Table 2-1.

Table 2-1. Summary of hazardous environmental conditions for the Port of Genoa, Italy.

| HAZARDOUS CONDITIONS | INDICATORS OF POTENTIAL HAZARD | VESSEL LOCATION/ SITUATION AFFECTED | EFFECT - PRECAUTIONARY/EVASIVE ACTIONS |
|---|---|---|---|
| 1. SE winds - Scirocco.<br>* Early stage Genoa lows.<br>* Cold season event, late October through April.<br>* Southerly flow east of low.<br>* Wind force 5-6 (17-27 kt), seas 6-10 ft (2-3m).<br>* Cloudy, rain, low visibility, thunderstorms embedded in layered clouds. | Advance warning<br>* Limited due to Genoa low forming in immediate area rather than approaching from distant area.<br>* Falling pressure Gulf of Genoa/Po Valley.<br>* Increasing southerly winds, clouds and precipitation.<br>* Genoa low development typically coincides with onset of Mistral wind in Gulf of Lion.<br>* Cold air entering Po Valley from the NE, nearly stationary Genoa low likely to develop.<br>Duration<br>* 1 to 2 days<br>Changes in wind<br>* Gradual increase<br>* Strongest just before shifting to SW | (1) Anchored - Outside Breakwater. | (a) ANCHORAGE FULLY EXPOSED TO OPEN SEA WIND/WAVE<br>* Port Authorities notify all ships in the area of high wind forecasts and recommend protecting at sea.<br>* Vessels should deploy second anchor.<br>* Wave reflection off breakwater causes choppy confused sea.<br>* Scirocco results in anomalous radar and radio transmission, helicopters liable to be out of radio contact at 1-2 n mi. |
| | | (2) Berthed/Anchored - Inner Harbor. | (a) WAVES ENTER HARBOR THROUGH ENTRANCE<br>* SE wind/waves affect berths/operations in outer portion of inner harbor.<br>* Add ropes.<br>* Vessels berthed at inside of breakwater in added threat due to lack of fenders, etc. Recommend departing berth. |
| | | (3) Arriving/Departing. | (a) HAZARDOUS MANEUVERING<br>* Reduced visibility and wind/wave action through harbor entrance.<br>* Delay until conditions improve. |
| | | (4) Small Boat Operations. | (a) OPERATIONS TO OUTER ANCHORAGE AREA MAY HAVE TO BE CANCELLED<br>* Traffic plus wind/waves action through harbor entrance causes added hazard.<br>* Larger contractor boats will run after Navy launches are secured. |
| 2. SW winds - Lebeccio.<br>* Two causes, Genoa low and/or Mistral winds.<br>* Cold season events, late October through April.<br>* Typical event lasts 1 to 2 days, force 5 (17-21 kt) with periods of force 8 (34-40 kt), seas 10-13 ft (3-4m).<br>* With Genoa low: Cloudy, rain, reduced visibility. Secondary front development causes intermittent periods of heavy weather.<br>* With Mistral: Fair weather, heavy SW sea and swell. | Advance warning<br>* Falling pressures Gulf of Genoa/Po Valley.<br>* Cold air entering Po Valley from northeast.<br>* Genoa low moving out of area.<br>* Frontal cloud band approaching.<br>Duration<br>* 1 to 2 days with Genoa low<br>Change in wind<br>* Will shift to north if low moves out, backs to SE in advance of secondary fronts. | (1) Anchored - Outside Breakwater. | (a) WORST CONDITIONS FOR FULLY EXPOSED ANCHORAGE AREA<br>* Port Authorities notify all ships in the area of high wind forecasts and recommend protecting at sea.<br>* Prepare to get underway as waves approach top of breakwater.<br>* Depart area when waters breach breakwater.<br>(b) Add second anchor if remaining.<br>(c) Wave refection off breakwater causes confused complex wave action.<br>* Cancel/delay/avoid alongside or well deck operations. |
| | | (2) Berthed/Anchored - Inner Harbor. | (a) STRONG WINDS AFFECT AREA CAUSE SHIP MOVEMENTS.<br>* Double lines and anchors.<br>* Depart berths at inner breakwater |
| | | (3) Arriving/Departing. | (a) HAZARDOUS MANEUVERING.<br>* Delay until high winds subside. |
| | | (4) Small Boat Operations. | (a) BOATING TO/FROM ANCHORAGE WILL BE AFFECTED.<br>* Moderate to strong events preclude small boat operations.<br>(b) Boating inside breakwater.<br>* May be hazardous in vicinity of harbor entrance. |

Table 2-1. (Continued)

| HAZARDOUS CONDITIONS | INDICATORS OF POTENTIAL HAZARD | VESSEL LOCATION/ SITUATION AFFECTED | EFFECT - PRECAUTIONARY/EVASIVE ACTIONS |
|---|---|---|---|
| 3. N winds - Tramontana.<br>* Typically follows Genoa low SE and SW winds.<br>* Cold season event, late October through April.<br>* Average force 5-6 (17-27 kt), occasionally force 8 (34-40 kt).<br>* Brings freezing temperatures and rarely snow.<br>* Seldom lasts more than a day.<br>* Likely force 8-9 (34-47) off coastal valleys. | Advance warning<br>* Clouds form over mountains to north.<br>Duration<br>* Less than a day.<br>Changes in wind<br>* Diminishes to weak N'erly during cold season. | (1) Anchored - Outside Breakwater. | (a) MINOR HAZARDS.<br>* Be aware of wind chill factor.<br>* Low temperature operations, on rare occasion snow showers.<br>(b) Strongest events offshore from mountain valleys.<br>* Experienced west of Genoa in coastal area. |
| | | (2) Berthed/Anchored - Inner Harbor. | (a) MINIMAL EFFECTS.<br>* Be aware of wind chill factor.<br>* Add lines/anchors. |
| | | (3) Arriving/Departing. | (a) MINIMAL EFFECTS.<br>* Ship handling may be affected due to winds. |
| | | (4) Small Boat Operations. | (a) BE AWARE OF WIND CHILL FACTOR.<br>* Protect personnel. |
| 4. Development of secondary fronts.<br>* Form with semi-stationary Genoa Low.<br>* May contain more violent weather than original front; squalls, thunderstorms, and sharp wind sheer. | Advance warning<br>* SW wind backs to S or SE.<br>Duration<br>* About 6 hours.<br>Changes in wind<br>* Backs to S to SE, increases by 10-15 kt, shifts to SW with passage. | (1) Anchored - Outside Breakwater. | (a) RECURRENCE OF HAZARDOUS CONDITIONS.<br>* Each secondary front can cause repeat sequence of SE to SW to N wind events.<br>* Closely monitor movement/evolution of Genoa low and Mistral wind events. |
| | | (2) Berthed/Anchored - Inner Harbor. | (a) RECURRENCE OF HAZARDOUS CONDITIONS.<br>* Each secondary front can cause repeat sequence of SE to SW to N wind events.<br>* Closely monitor movement/evolution of Genoa low and Mistral wind events. |
| | | (3) Arriving/Departing. | (a) RECURRENCE OF HAZARDOUS CONDITIONS.<br>* Each secondary front can cause repeat sequence of SE to SW to N wind events.<br>* Closely monitor movement/evolution of Genoa low and Mistral wind events. |
| | | (4) Small Boat Operations. | (a) RECURRENCE OF HAZARDOUS CONDITIONS.<br>* Each secondary front can cause repeat sequence of SE to SW to N wind events.<br>* Closely monitor movement/evolution of Genoa low and Mistral wind events. |

## SEASONAL SUMMARY OF GENOA HAZARDOUS WEATHER CONDITIONS

WINTER (November through February): Wet and Windy.

* Southwesterly winds and waves: called Lebeccio, caused by Gulf of Genoa lows; rapid onset, winds increase from force 5 (17-21 kt) to force 8 (34-40 kt) within 30 minutes. Waves 10-13 ft (3-4 m) will break over breakwater. Wave reflection off breakwater results in complex rough wave action in anchorage area.
* Genoa lows move out slowly, conditions may exist for 24 hr or more. Secondary fronts spokewheel around primary low resulting in several periods of heavy weather.
* Strong southwesterly winds (Mistral) occurring to the west along coast of France can result in heavy southwest swell causing problems in anchoring or entering harbor (Brody and Nestor, 1980).
* Strong northerly (Tramontana) wind to force 8-9 (34-47 kt) occurs to seaward of mountain valley east of Genoa.

SPRING (March through May): Off and on transition, winter to summer conditions.

* Southerly winds and waves during first half similar to winter.

SUMMER (June through September):

* Occasional thunderstorms

AUTUMN (October): Rapid transition to winter.

* Occasional thunderstorm
* Rapid return to winter conditions

NOTE: For more detailed information on hazardous weather conditions, see previous Summary Table in this section and Hazardous Weather Summary in Section 3.

## REFERENCE

Brody, L.R. and M.J.R. Nestor, 1980: Regional Forecasting Aids for the Mediterranean Basin, NAVENVPREDSCHFAC Technical Report TR 80-10. Naval Environmental Prediction Research Facility, Monterey, California 93941.

FICEURLANT, 1987: Port Directory for Genoa, Italy. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

## PORT VISIT INFORMATION

AUGUST 1987. NEPRF meteorologists R. Fett and D. Perryman met with the Port Captain and the Chief Pilot to obtain much of the information included in this port evaluation.

## 3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards and Table 3-2 provides a summary of vessel locations/situations, potential hazards, effects-precautionary/evasive actions, and advance indicators and other information by season.

### 3.1 Geographic Location

The Port of Genoa, the leading seaport and principal ship repair center of Italy, is located on the coast of northwestern Italy at approximately 44°25'N 8°57'E (Figure 3-1). It is on the extreme north shore of the Ligurian Sea, about 230 n mi northwest of Gaeta.

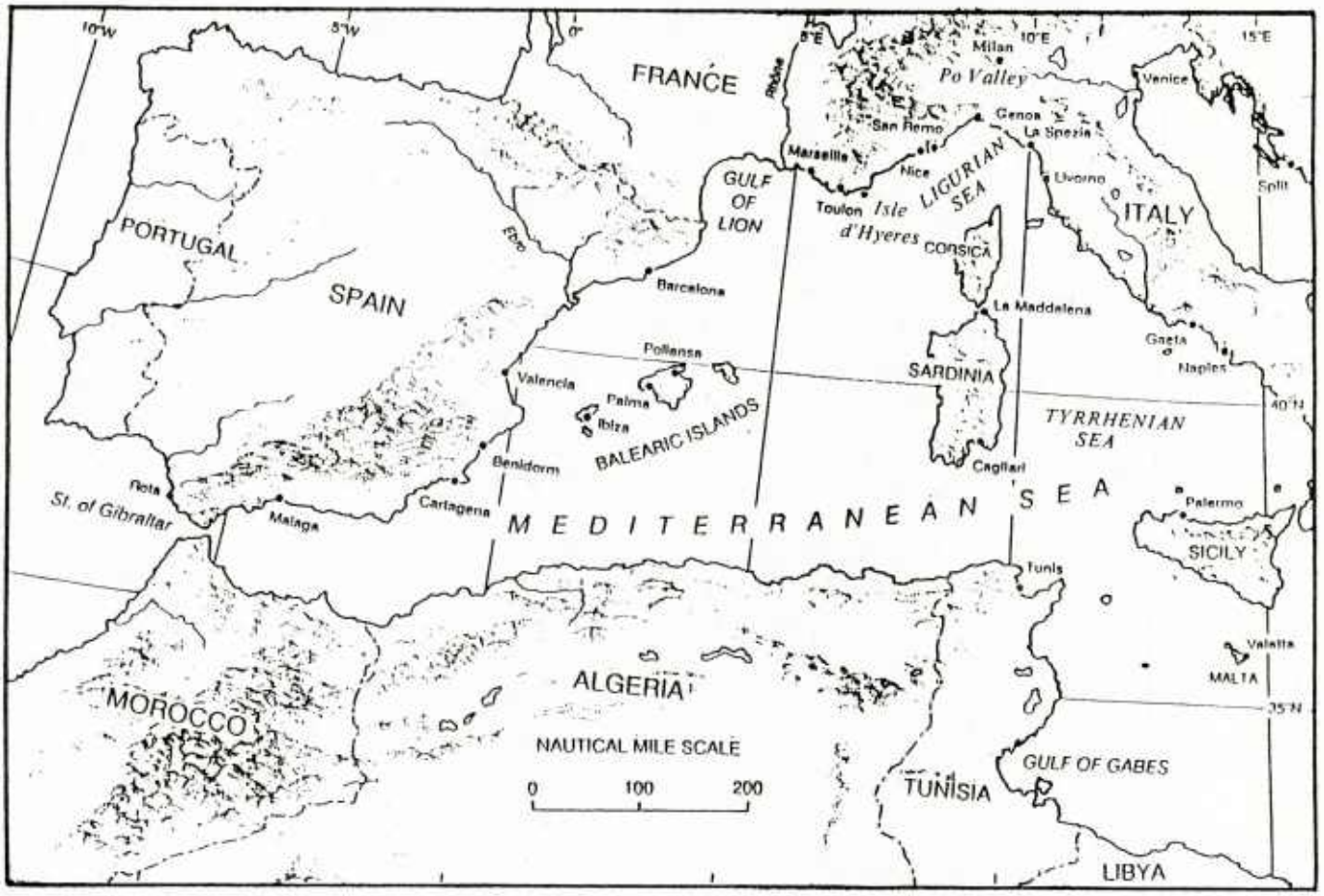



Figure 3-1. Western Mediterranean Sea.

The Port is situated near the northern most part of the Gulf of Genoa (Figure 3-2) where 2500-3000 ft coastal mountains are within a few miles of the coast (Hydrographer of the Navy, 1965). The city of Genoa is located about 43 n mi west-northwest of La Spezia or 80 n mi northeast of Nice. The northern most point of the Island of Corsica lies 86 n mi to the south of the Port.

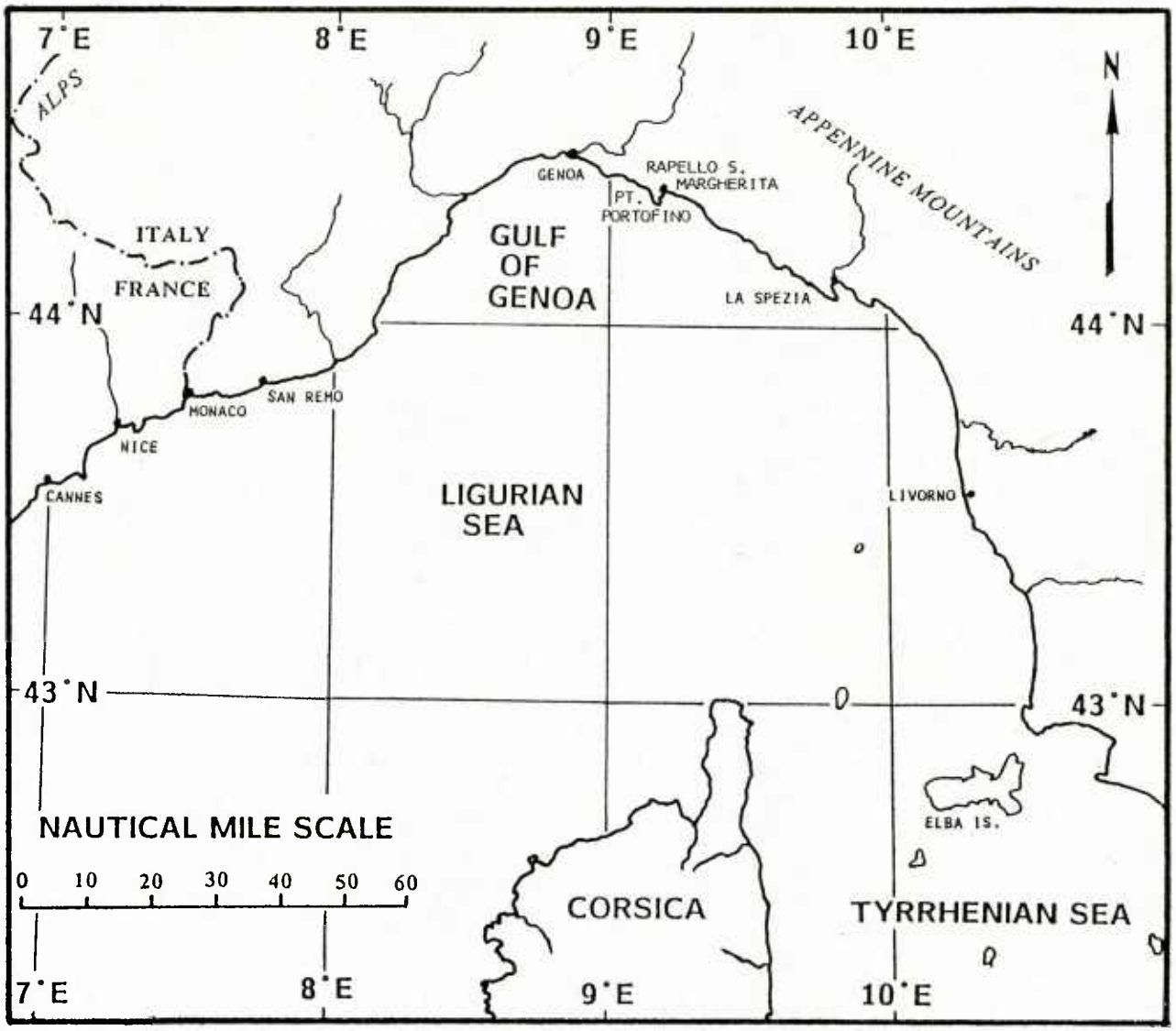



Figure 3-2. Northwest Coast of Italy and Gulf of Genoa Area.

The Primary berth is the quay wall at Calata Zingari, adjacent to the Maritime Station (Figure 3-3). Naval ships normally mediterranean moor, because the pier side berths are usually being used by passenger ships (FICEURLANT, 1987). Berthing on the inside of Molo Duca Galliera is not preferred due to the lack of fenders, bumpers, camels, etc. and the occurrence of surging due to any one of the following factors: (1) seas or swell from the east-southeast to south-southwest, (2) small barometric pressure fluctuations, and (3) frequent large ship traffic. These surges cause little vertical movement but will generate significant horizontal movement which poses potential damage to a moored ship.

The primary anchorage is one (1) n mi south of the breakwater (see Figure 3-3). The fleet landing is located at Ponte Dei Mille, adjacent to Calata Zingari. The anchorage depths are 25 fathoms or more with a mud bottom which provides good holding. However, at least one case of a tanker dragging a single anchor and wrecking on the breakwater has occurred in recent years during strong southwesterly wind/swell conditions. A second anchorage area is located about 15 n mi southeast of Genoa in a small gulf between the mainland and Point Portofino. The fleet landing for this anchorage is at Rapello Santa Marghetia.

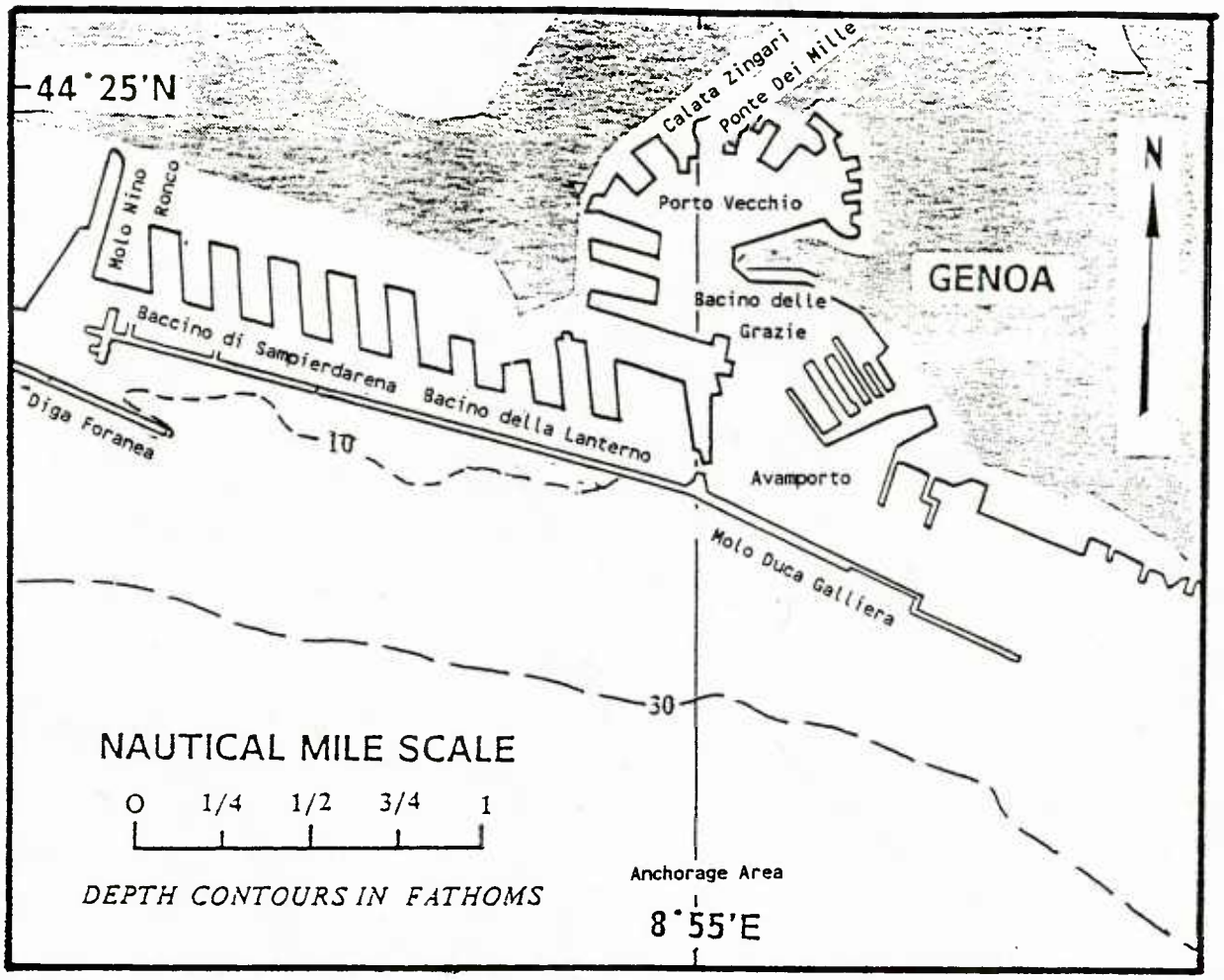



Figure 3-3. Port of Genoa.

## 3.2 Qualitative Evaluation of the Port of Genoa

The harbor area of Genoa inside the breakwaters is well protected from wave action. However, strong winds from any direction will cause ship movements. Ships with large sail area are particularly vulnerable. Under high wind condition ships should double mooring lines or depart and protect at sea.

Port authorities notify all ships in the area of high wind forecasts and recommend protecting at sea if not berthed. Ships at anchorage outside the breakwater should prepare to depart when waves approach the top of the breakwater, and depart the area for the open sea when the waves breech the breakwater. If vessels remain at anchor, double anchors are recommended.

Berthing on the inside of Molo Duca Galliera is hazardous to ships due to the lack of fenders and bumpers. Significant horizontal movement of ships will be experienced during heavy weather and large vessel movement in and out of the harbor entrance.

Contractor boats will continue to operate beyond the conditions that cancel Navy launches.

## 3.3 Currents and Tides

Both tides and currents are negligible in the harbor. Outside the harbor on east to west current of 1.0 to 1.5 kt exists. This current increases in speed during strong southeasterly wind conditions. Surges caused by ships traffic, incoming sea/swell and/or barometric pressure changes are of concern in the outer harbor near the harbor entrance to ships that are berthed in that area.

## 3.4 Visibility

Visibility at Genoa is good during the warm season. In the cooler months it is frequently reduced by fog but is rarely less than 2 n mi. During the fall and winter many days are characterized by dreary conditions of reduced visibility, low clouds and rain.

## 3.5 Hazardous Conditions

Genoa is located on the north shore of the Gulf of Genoa, one of the most active areas of cyclogenesis in the world. Consequently, it is subject to frequent periods of unstable, inclement weather, mainly during the autumn, winter, and spring seasons. Genoa is wetter than most places in the Mediterranean, receiving an average of 51 inches of precipitation a year. A seasonal summary of various known environmental hazards that may be encountered in the Port of Genoa area follows:

### A. Winter (November through February)

The winter conditions are wet and cool with frequent periods of squally blustery weather associated with Genoa lows. A particularly hazardous trait of the Genoa low is that several periods of squally frontal type weather is likely to occur with each low. This condition stems from the combined effects of the low being slow to move out and the development of secondary troughs or fronts. The strongest wind events at Genoa occur with southwest winds. Locally southwest winds are known as Lebeccios. There are two major causes: (1) the circulation associated with a Genoa low, and (2) Mistral winds which spread eastward from the Gulf of

Lion. The Genoa low winds are the most common. In winter the Lebeccio typically averages force 6 to 7 (22-33 kt), but may reach force 8 (34-40 kt) for periods of a few hours. Associated waves at the anchorage will be 10 to 13 ft (3 to 4 m). Swell waves to 10 ft (3 m) may last for 12 to 24 hours after Lebeccio winds abate.

The prevailing winter winds during non-disturbed periods are northwest-northeast (offshore) at about 10 kt. Stronger northerly wind events (Tramontana) of about force 5 (17-21 kt), but occasionally to force 8 (34-40 kt), occur as a Genoa low moves eastward. Stronger northerly winds are found offshore from coastal valleys west of Genoa.

Precipitation is common during this season, with an average seasonal accumulation of about 20 inches. Rain falls on 7 to 9 days per month with a 0.4 inches or more on about half the days. While not commonly seen, occasional snowfalls are recorded at Genoa. The snow usually melts quickly as temperatures return to their normal 40°-55° winter daily range.

The months of January and February are the coldest of the year, with a daily minimum of about 43°F (6°C) being normal for the period. The median high for the same period is near 52°F (11°C). Because of the relatively low temperatures that are common at Genoa during winter, wind chill (the effect of temperature combined with wind) should be considered when personnel are required to work outside in exposed locations. Table 3-1 can be used to determine the wind chill factor for various temperature and wind combinations.

Table 3-1. Wind Chill. The Cooling power of the wind expressed as "Equivalent Chill Temperature" (adapted from Kotsch, 1983).

| Wind Speed | | Cooling Power of Wind expressed as "Equivalent Chill Temperature" | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Knots | MPH | Temperature (°F) | | | | | | | | |
| Calm | Calm | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 |
| | | Equivalent Chill Temperature | | | | | | | | |
| 3-6 | 5 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
| 7-10 | 10 | 30 | 20 | 15 | 10 | 5 | 0 | -10 | -15 | -20 |
| 11-15 | 15 | 25 | 15 | 10 | 0 | -5 | -10 | -20 | -25 | -30 |
| 16-19 | 20 | 20 | 10 | 5 | 0 | -10 | -15 | -25 | -30 | -35 |
| 20-23 | 25 | 15 | 10 | 0 | -5 | -15 | -20 | -30 | -35 | -45 |
| 24-28 | 30 | 10 | 5 | 0 | -10 | -20 | -25 | -30 | -40 | -50 |
| 29-32 | 35 | 10 | 5 | -5 | -10 | -20 | -30 | -35 | -40 | -50 |
| 33-36 | 40 | 10 | 0 | -5 | -15 | -20 | -30 | -35 | -45 | -55 |

B. Spring (March through May)

The spring season in the central Mediterranean Sea is characterized by periods of stormy winter-type weather associated with a continued high frequency of Genoa lows, which alternate with a number of false starts of relatively settled-summer type weather (Brody and Nestor, 1980). Although Genoa lows can develop during any month, the strongest spring systems occur in March and April. By May, the transition to the more-or-less settled weather of summer proceeds more smoothly.

Southwesterly Lebeccio winds are possible throughout the season as low pressure systems move into or develop in the Gulf of Genoa. Strongest winds are to be expected in March and April. Since late winter and early spring is the period of maximum Mistral frequency and strength in the Gulf of Lion, Lebeccio winds at Genoa which result from an eastward spreading of Mistral winds would also be more frequent and stronger during the same period. In either case, strong Lebeccio winds would be rare and of short duration by the end of May.

Springtime precipitation is at a maximum during March, when an average of 5.7 inches falls. Monthly totals decrease through April to May, when about 3.7 inches can be expected during an average month. Snow has been recorded during April, but is a very rare occurrence. Thunderstorms are possible, and are most probable with the development of secondary fronts during strong Genoa low events.

An increase in temperature occurs throughout the season. By May the mean daily maximum and minimum temperatures are 69°F (21°C) and 59°F (15°C) respectively. Wind chill should be considered for personnel working outdoors in exposed locations through mid-April. See Table 3-1.

C. Summer (June through September)

The Summer season brings warm relatively settled weather to Genoa. Lebeccio events are rare and of short duration. A sea/land breeze regime is evident. Evening through early morning winds blow from north clockwise through south and from the southeast to south during afternoons. Speeds are light and have negligible effect on harbor operations.

Precipitation reaches its minimum during mid-summer with an average accumulation during July, the driest month, of about 1.9 inch. August is nearly as dry (2.1 in) with September rainfall increasing to 4.3 inches. Thunderstorms may occur during late summer, but are usually widely scattered.

July and August have the highest average temperatures of the year, with about 80°F and 71°F being the mean daily maximum and minimum temperatures.

D. Autumn (October)

According to Brody and Nestor, (1980), the autumn season lasts only for the single month of October, and is characterized by an abrupt change to winter-type weather.

The transition to winter-type weather brings an increase in frequency and intensity of Genoa cyclogenesis, and attendant Lebeccio winds at Genoa.

Precipitation amounts continue to increase from the relatively low totals of summer with 7.1 inches being recorded during an average October.

Temperatures decrease from those of late summer, but are still moderate, with 67°F (20°C) and 58°F (14°C) being the mean daily maximum and minimum figures for the month.

## 3.6 Harbor Protection

Very little wave action is felt at the berths in the inner harbor. However, strong winds from any direction will cause ship movements, especially those with large sail areas. It is advisable to add ropes or sortie to the open sea in high wind conditions. The outer harbor and entrance area are affected by southeasterly waves generated by Scirocco events (southeasterly winds). The waves enter the southeast facing entrance as well as being reflected off the shore and result in choppy confused wave action.

### 3.6.1 Wind and weather

Because of its location south of the Alps mountain range and at the enclosed end of a gulf frequent cyclogenesis occurs in the area. In fact, the Gulf of Genoa has one of the highest frequencies of

cyclone development during the cold season of any place on earth. Genoa has a greater annual rainfall than most any place in the Mediterranean (51 inches).

There are typically three high wind producing patterns for this area. The development of a Genoa low, a mistral outbreak off the southern coast of France, and strong northerly offshore flow as a migratory trough and following ridge pattern pass eastward over central Europe.

A Genoa low event has a typical wind pattern starting with southeasterlies (Scirocco), becoming southwesterly (Lebeccio) as the center slowly moves eastward, and then shifting to northerly (Tramontana) as the low moves on. In advance of these lows, gusty southeasterly winds prevail with scattered thunderstorm activity. Because the Genoa lows tend to remain over the Gulf area for a day or more, there is time for the initial frontal passage (typically not containing the most severe weather) to be followed by one or more passages of secondary fronts. The development of a Genoa low is often signaled by strong upper level west to northwest winds over the Gulf of Lions a day or two in advance of the development.

The southwesterly (Lebeccio) wind events are caused by two different mechanisms. First, the Genoa low as previously discussed which is accompanied by cloudy skies and reduced visibility. The second is the mistral events where cold dense air flows off the land into the Gulf of Lion as a northerly wind. This outflow then becomes a westerly wind as it spreads eastward along the coast of southern France and finally southwesterly in the Genoa area. The Mistral related southwesterly flow is normally accompanied by clear skies and good visibility. In both types wind speeds are often over 30 kt and are characterized by rapid

increases and decreases in speed, likely due to the coastal terrain influences and land/sea temperature contrasts.

Light northerly winds (Tramontana) are the typical winter condition during non-disturbed periods. Strong offshore events also occur and bring the coldest temperatures to Genoa. Freezing temperatures and snow do occur on occasion, such as on 6 January 1985. These cold outbreaks are usually of short duration with a return to normal temperatures and melting of the snow within 48 hours.

### 3.6.2 Waves

The inner harbor is well protected from waves. The outer harbor and harbor entrance will experience troublesome wave action during periods of strong southeasterly winds.

Vessels at anchor in the primary anchorage outside the harbor breakwater are exposed to the open sea wave action. The worst conditions occur during strong southwesterly winds (Lebeccio) which can increase from force 5 (17-21 kt) to force 8 (34-40 kt) within 30 minutes. Waves of 10 to 13 ft (3 to 4 m) develop during the stronger events and will break over the 13 to 20 ft (4 to 6 m) breakwater. Swell waves to 10 ft (3 m) will persist for 12 to 24 hours after Mistral related southwesterly winds abate. Ships at anchor within a couple miles south of the breakwater must also contend with wave reflection off the breakwater. This results in confused choppy multiple direction/period wave action that is particularly hazardous to small boats and along side operations of vessels of different length and wave response characteristics.

## 3.7 Protective and Mitigating Measures

### 3.7.1 Sortie/Remain in Port

The Port Authorities notify all ships in the area when high winds are forecast and recommend protecting at sea if not safely berthed. A rule of thumb is to get ready to depart as waves approach the top of the breakwater, when waves breech the breakwater, depart. Ships berthed should add ropes during high wind events. Berthing at the inside of the breakwater (Molo Duca Galliera) is particularly hazardous during high wind/wave periods due to wave and wind action and surges through the harbor entrance which cause horizontal ship motions and the potential for damage due to the lack of adequate fenders, bumpers, etc.

### 3.7.2 Moving to a New Anchorage

The anchorage between Point Portofino and the mainland, located about 15 n mi southeast of Genoa, is considered one of the most protected anchorages in the area.

## 3.8 Local Indicators of Hazardous Weather Conditions

The inner harbor at the Port of Genoa is well sheltered from waves, but is vulnerable to the direct effect of strong wind. The anchorage is located outside the protective breakwater system, and is exposed to the effects of open sea winds and waves. Consequently, it is prudent to be aware of forthcoming hazardous weather events. The following guidelines have been compiled from various sources, including on-site interviews with local authorities at Genoa. They are intended to provide

additional insight to Fleet meteorologists and enable them to recognize events that indicate changes in weather conditions.

### 3.8.1 Site Visit and Fleet Publication Insights

Local authorities and fleet publications provide the following indicators of the onset or character of hazardous weather conditions.

A. Onset

(1) Genoa low development

(a) Strong west to northwest winds aloft over the Gulf of Lion signal the development of a Genoa low within one to two days.

(b) Surface pressure falls over the Gulf of Genoa and/or Po Valley indicates beginning stage of development.

(c) Commencement of Mistral wind event in Gulf of Lion typically coincides closely with a closed low developing in the Gulf of Genoa.

B. Associated weather events

(1) Genoa low development

(a) Genoa lows remain nearly stationary during development.

(b) Winds start out as southeasterlies, shift to southwesterlies and then northerlies as low moves out.

(c) If winds have shifted to southwest and then back to southeast, expect passage of a secondary front.

(d) If clouds start coming over mountains from the north, southwesterly wind will shift to northerly and low is moving out.

(2) Frontal systems

(a) Frontal systems are not as good an indication of weather patterns in the Mediterranean as in higher latitudes. The leading frontal system tends to dissipate and be replaced by secondary fronts as systems move from west to east. Air mass differences are important factors in explaining/forecasting Mediterranean weather.

(3) Southwesterly (Lebeccio) winds

(a) Clouds building over mountains from the north indicates the surface southwesterlies at Genoa will end shortly and shift to northerlies.

(b) When Mistral type southerwesterlies are approaching they will likely stop short of Genoa if there is snow on the mountains to the north. Strong southwesterlies may be occurring at Capo delle Melle (43°57'N 8°10'E) while Genoa has calm or light northerly winds.

(4) Southwest swell

(a) Southwest swell is reflected off the coast in the region southeast of Genoa resulting in uncomfortable and occasionally dangerous conditions. Especially noticeable off Portofino where the condition may be felt up to 2.5 n mi offshore.

3.8.2 NEPRF Technical Report Insights

Unless otherwise indicated, the following guidelines have been adapted from Regional Forecasting Aids for the Mediterranean Basin, NAVENVPREDRSCHFAC Technical Report TR 10-80, authored by L.R. Brody and LCDR M.J.R. Nestor, RN and published by Naval Environmental Prediction Research Facility, Monterey,

California 93941 in December 1980.

A. Genoa lows, the most frequent cause of strong southwesterly winds (Lebeccio) at Genoa.

(1) Cyclogenesis

(a) A lee trough often is present in the Gulf of Genoa when a cold or occluded front is moving into western France. This lee trough remains stationary until the arrival of the front, at which time significant cyclogenesis occurs.

(b) A good indication of rapid development of a Genoa low is the appearance of cold air from the northeast in the Po Valley of northern Italy.

(c) If Genoa cyclogenesis is predicted, the following rules can be used to decide whether it will occur in the Gulf of Genoa or to the east in the Gulf of Venice:

1 If large amounts of cold air penetrate the Po Valley from the northeast, cyclogenesis can be expected in the Gulf of Genoa. This cyclone generally will move southeastward along the west coast of Italy.

2 If little cold air penetrates the Po Valley from the northeast while a strong push is observed in the Gulf of Lion, cyclogenesis will probable take place in the Gulf of Venice. This cyclone occasionally may move southeast through the Adriatic Sea.

(d) Genoa lows occur almost simultaneously with the onset of the Mistral in the Gulf of Lion, and invariably form when conditions are right for the Mistral to occur.

(e) Complex low pressure systems with multiple centers at the surface are a common event in the western Mediterranean Basin. One center usually can be found in the Gulf of Genoa, while another is found

over North Africa; a weak pressure gradient exists between the two systems. Which of these lows will develop depends greatly on the movement of an upper-level (500 mb) short wave trough. If the trough moves to the North African coast, for example, the low center in that region will develop rapidly, increasing the pressure gradient and causing easterly gales over the southern Tyrrhenian Sea.

(2) Associated wind and weather

(a) Weak to moderate Genoa cyclogenesis causes important variations in the weather along the west coast of Italy. When analyzing these cases, the resolution of the 500 mb analysis should be fine enough to support tracing of the weak short wave troughs associated with increased shower activity.

(b) Convective activity associated with a Genoa low has a periodicity of about 18 hr, starting with the initial cold frontal passage. The periodicity is most pronounced with a stationary low. The most intense convective activity occurs at 36 hr intervals.

(c) Strong northerly winds can be expected in the Gulf of Genoa within 6-8 hrs if (1) the 1034 mb isobar is present along the crest of the alps north of the Gulf of Genoa and (2) increasing northerly winds are observed at Milan (16080).

(3) Miscellaneous

(a) A residual low pressure trough generally remains over the Gulf of Genoa even after the primary low has moved well out of the region. The trough can remain for several days.

(b) Centers of Genoa lows can be poorly organized: strong pressure gradients, associated with a lee trough south of the Alps, frequently are found far from the low's geographic center.

B. Strong Mistral outbreaks over the Gulf of Lion. The following is an abbreviated listing of various guidelines which address the Mistral. For a more comprehensive listing see the NEPRF Severe Weather Guide for Marseille or Toulon, France.

(1). Frequency and rationale - According to Brody and Nestor (1980), strong westerly winds associated with Mistral conditions rarely reach the west coast of Italy. The winds spread south of the Gulf and turn eastward. The induced low pressure in the Ligurian Sea assists the wind in turning until the direction becomes west-southwest in the Livorno area.

(2). Causes - According to Brody and Nestor (1980), the Mistral is the result of a combination of the following factors:

(a) A basic circulation that creates a pressure gradient from west to east along the coast of southern France. This pressure gradient is normally associated with Genoa cyclogenesis.

(b) A fall wind effect caused by cold air associated with the Mistral moving downslope as it approaches the southern coast of France and thus increasing the wind speed.

(c) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia.

(d) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).

(3). Onset - A Mistral will start in the Gulf of Lion when one of three pressure differences is achieved: Perpignan - Marignane (Marseille), 3 mb; Marignane - Nice, 3 mb; or Perpignan - Nice, 6 mb. A difference usually occurs from 0-24 hr after a closed Genoa low appears, but it occasionally occurs earlier.

(4). Intensity

(a) Strongest winds associated with a Mistral do not occur until after the passage of the upper level (500 mb) trough. This occurs well after the surface cold frontal passage.

(b) The table below may be used to estimate wind speed associated with a Mistral in the Gulf of Lion.

| Pressure Difference (mb) | Perpignan* (07747) and Nice (07690) | Perpignan* and Marignane (07650) | Marignane** and Nice |
|---|---|---|---|
| 3 | | 30-35 kt | 30-35 kt |
| 4 | | 40 | 40 |
| 5 | | 45-50 | 45-50 |
| 6 | 30-35 kt | | |
| 8 | 40 | | |
| 10 | 45-50 | | |

* Highest pressure at Perpignan
** Highest pressure at Marignane

(5). Extent - There is a rapid decrease in the frequency and average force of the Mistral east of Iles d'Hyeres. On many occasions, light easterlies are reported from Nice when strong northwesterlies are blowing at Marseille (Hydrographer of the Navy, 1965). Alongshore pressure gradient is important in predicting Mistral extent and intensity. When a 10 mb difference exists between Toulon and Nice, the Mistral will spread eastward. With only a 2 mb difference between Marseille and Toulon, the mistral will cease near Toulon. The eastern boundary of the Mistral usually extends downwind from the western edge of the Alps through San Remo, Italy (Brody and Nestor, 1980).

### 3.8.3 Miscellaneous Sources Insights

A. Past experience indicated that the reliability of hourly reporting stations along the Italian coast is questionable, especially during the night.

B. During periods of southerly surface flow in the central Mediterranean, convergence zones between southeasterly and southwesterly winds are frequently observed. These convergence zones result in heavier precipitation and lower visibilities. Fronts are not associated with this phenomenon initially, but may develop later.

C. During the winter half of the year along the west coast of Italy, maximum occurrence of convective activity is in the early morning (0300-0800L) and minimum occurrence is in the late afternoon and early evening. In the mountains to the east, however, this diurnal variation is reversed.

D. Dry, moderate-to-strong (15-25 kt), north-to east winds during the winter have produced steam fog along the Italian coast from Genoa to Pisa, (about 14 n mi north-northeast of Livorno) out to 35 n mi offshore. Visibilities in this fog are reduced to 1-2 n mi although the dewpoint-temperature spread measured at an aircraft carrier's flight deck level may exceed 4°F.

## 3.9 Summary of Problems, Actions, and Indicators

Table 3-2 is intended to provide easy to use seasonal references for meteorologists on ships using the Port of Genoa. Table 2-1 (Section 2) summarizes Table 3-2 and is intended primarily for use by ship captains.

Table 3-2. Potential problem situations at Port of Genoa, Italy - ALL SEASONS

| VESSEL LOCATION/ SITUATION AFFECTED | POTENTIAL HAZARD | EFFECT - PRECAUTIONARY/EVASIVE ACTIONS | ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD |
|---|---|---|---|
| 1. Anchored - Outside Breakwater.<br><br>Cold season event late October through April | a. SW'ly winds/waves - Lebeccio. Associated with Genoa lows or Mistral events. Causes most hazardous conditions at outer anchorage. Typically 17-21 kt (Force 5) with periods of 34-40 kt (Force 8), seas 10-13 ft (3-4m) for 1 to 2 day duration, may persist for longer. With nearly stationary Genoa low, development of secondary fronts result in several periods of high winds/seas and persistent cloudy, rain and reduced visibility. With Mistral, fair weather but heavy SW sea and swell. | a. Most hazardous conditions for outer anchorage. Port Authorities recommend protecting at sea. Add second anchor if remaining. Wave reflection off breakwater causes complex wave action, cancel small boats and alongside or well deck operations. Prepare to depart as waves approach top of breakwater, depart when waves breech breakwater. | a. Genoa area winds will first freshen from the SE during Genoa low development. Port Authorities notify all ships in area of high wind forecasts. Falling pressure Gulf of Genoa/Po Valley and/or cold air entering Po Valley from northeast indicate Genoa low formation. Approaching frontal bands will be evident on satellite imagery. Mistral events in area follow mistral development over Gulf of Lion. |
| Cold season event late October through April | b. SE'ly winds/waves - Scirocco. Early stages of Genoa low development. Winds 17-27 kt (force 5-6), seas building to 6-10 ft (2-3 m). Cloudy, rain, low visibility with thunderstorms embedded in layered clouds. | b. Increasing winds, building seas, deploy second anchor. Prepare for wind shifting to SW and increasing, may necessitate sortie. Anomalous radar and reduced radio ranges develop. | b. Limited due to in situ development of Genoa lows. Pressure falls in Po Valley and Gulf of Genoa indicates low development. Typically coincides with Mistral wind events in Gulf of Lion. |
| Cold season event late October through April | c. N'ly winds - Tramontana. Near freezing temperatures, low wind chill. Strongest winds 34-40 kt (force 8) offshore from valleys/mouth of rivers to west of Genoa. | c. Be aware of wind chill hazards during coldest months. Expect strong offshore winds 34-40 kt (force 8-9) seaward from mountain valleys/mouths of rivers within a few miles of coastline. | c. Clouds forming over mountains from the north indicator of winds shifting to north. Duration generally less than a day, marks the eastward movement of Genoa lows. |
| 2. Berthed/Anchored Inner Harbor.<br><br>Cold season event late October through April | a. SE'ly winds/waves - Scirocco. Early stages of Genoa low development. Winds 17-27 kt (force 5-6), seas building to 6-10 ft (2-3m). Cloudy, rain, low visibility with thunderstorms embedded in layered clouds. | a. Waves enter harbor through southeast facing entrance affecting berths/operations in outer portion of inner harbor. Vessels berthed at inner side of breakwater should move to new berth/anchorage, elsewhere add lines. | a. Limited due to in situ development of Genoa lows. Pressure falls in Po Valley and Gulf of Genoa indicate low development. Typically coincides with Mistral wind events in Gulf of Lion. |
| Cold season event late October through April | b. N'ly winds - Tramoutana. Near freezing temperatures, low wind chill. Winds in harbor typically 17-21 kt (force 5). | b. Ships may be moved off berths, add/double lines. Deck/pier side operations should consider wind chill factor. | b. Clouds forming over mountains from the north indicator of winds shifting to north. Genoa low moving eastward causes wind shift to north. |
| Cold season event late October through April | c. SW'ly winds/waves - Lebeccio. Strong winds may cause ship movements and steerage problems. | c. Ships may be moved off berths or swing at anchor. Add lines/anchors. | c. With Genoa low SW'ly follow Se'lies of early low development stage. With Mistral, high winds occur first in Gulf of Lion and advance eastward along coast. |

Table 3-2 (Continued)

| VESSEL LOCATION/ SITUATION AFFECTED | POTENTIAL HAZARD | EFFECT - PRECAUTIONARY/EVASIVE ACTIONS | ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD |
|---|---|---|---|
| 3. Arriving/Departing.<br><br>Cold season event late October through April | a. SE'ly winds/waves - Scirocco. Early stages of Genoa low development. Winds 17-27 kt (force 5-6), seas building to 6-10 ft (2-3 m). Cloudy, rain, low visibility with thunderstorms embedded in layered clouds. | a. Increasing winds, building seas, deploy second anchor. Prepare for wind shifting to SW and increasing, conditions may necessitate sortie. Anomalous radar and reduced radio ranges develop. | a. Limited due to in situ development of Genoa lows. Pressure falls in Po Valley and Gulf of Genoa indicate low development. Typically coincides with Mistral wind events in Gulf of Lion. |
| Cold season event late October through April | b. SW'ly Winds/Waves - Lebeccio. Associated with Genoa lows or Mistral events. Causes most hazardous conditions outside of harbor. Typically 17-21 kt (Force 5) with periods of 34-40 kt (Force 8), seas 10-13 ft (3-4m) for 1 to 2 day duration, may persist for longer. With nearly stationary Genoa low, development of secondary fronts result in several periods of high winds/seas and persistent cloudy, rain and reduced visibility. With Mistral, fair weather but heavy SW sea and swell. | b. Most hazardous condition outside harbor. Wave reflection off breakwaters and coastline causes confused sea conditions out to a couple miles offshore. High winds and busy harbor combine for hazardous maneuvering in harbor entrance. | b. Genoa area winds will first freshen from the SE during Genoa low development. Port Authorities notify all ships in area of high wind forecasts. Falling pressure Gulf of Genoa/Po Valley and/or cold air entering Po Valley from northeast indicate Genoa low formation. Approaching frontal bands will be evident on satellite imagery. Mistral events in area follow mistral development over Gulf of Lion. |
| Cold season event late October through April | c. N'ly Winds - Tramontana. Near freezing temperatures, low wind chill. Strongest winds 34-40 kt (force 8) offshore from valleys/mouth of rivers to west of Genoa. | c. Be aware of wind chill hazards during coldest months. Expect strong offshore winds 34-47 kt (force 8-9) seaward from mountain valleys/mouths of rivers within a few miles of coastline. | c. Clouds forming over mountains from the north indicator of winds shifting to north. Duration generally less than a day, marks the eastward movement of Genoa lows. |
| 4. Small Boat Operations.<br><br>Cold season event late October through April | a. SW'ly winds/waves - Libeccio. High winds, seas and swell. Complex wave conditions due to reflection off breakwater. | a. Cancellation of small boat operations outside harbor. | a. With Genoa low SW'ly winds follow SE'lies of early low development stage. With Mistral, high winds occur first in Gulf of Lion and advances eastward along coast. |
| Cold season event late October through April | b. SE'ly winds/waves - Scirocco. Early stages of Genoa low development. Winds 17-27 kt (force 5-6), seas building to 6-10 ft (2-3 m). Cloudy, rain, low visibility with thunderstorms embedded in layered clouds. | b. Increasing wind and waves plus reduced visibility may necessitate cancelling small boat operations outside harbor. | b. Limited due to in situ development of Genoa lows. Pressure falls in Po Valley and Gulf of Genoa indicate low development. Typically coincides with Mistral wind events in Gulf of Lion. |

## REFERENCE

Brody, L.R. and M.J.R. Nestor, 1980: Regional Forecasting Aids for the Mediterranean Basin, NAVENVPREDSCHFAC Technical Report TR 80-10. Naval Environmental Prediction Research Facility, Monterey, California 93941.

Hydrographer of the Navy, 1965: Mediterranean Pilot, Volume II. Hydrographer of the Navy, London, England.

Kotsch, W.J. 1983: Weather for the Mariner, Naval Institute Press, Annapolis, Maryland.

FICEURLANT, 1987: Port Directory for Genoa, Italy. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

## PORT VISIT INFORMATION

AUGUST 1987. NEPRF meteorologists R. Fett and D. Perryman met with the Port Captain and the Chief Pilot to obtain much of the information included in this port evaluation.

# APPENDIX A

## General Purpose Oceanographic Information

This section provides some general definitions regarding waves and is extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955).

### Definitions

Waves that are being generated by local winds are called "SEA". Waves that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN- BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period ($f = 1/T$) therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A Beaufort Scale table with related wave effects is shown on the following page.

## BEAUFORT SCALE

| Beaufort Number | Wind Speed Knots | Wind Speed MPH | Seaman's term | Effects observed at sea | Term and height of Waves in meters |
|---|---|---|---|---|---|
| 0 | Under 1 | Under 1 | Calm | Sea like mirror. | Calm, glassy, 0 |
| 1 | 1-3 | 1-3 | Light air | Ripples with appearance of scales; no foam crests. | |
| 2 | 4-6 | 4-7 | Light breeze | Small wavelets; crests of glassy appearance, not breaking | Rippled, less than 0.5 |
| 3 | 7-10 | 8-12 | Gentle breeze | Large wavelets; crests begin to break; scattered whitecaps. | Smooth, 0.5 |
| 4 | 11-16 | 13-18 | Moderate breeze | Small waves, becoming longer; numerous whitecaps. | Slight, 1.0 |
| 5 | 17-21 | 19-24 | Fresh breeze | Moderate waves, taking longer form; many whitecaps; some spray. | Moderate, 1.0-2.5 |
| 6 | 22-27 | 25-31 | Strong breeze | Larger waves forming; whitecaps everywhere; more spray. | Rough, 2.5-4.0 |
| 7 | 28-33 | 32-38 | Moderate gale | Sea heaps up; white foam from breaking waves begins to be blown up in streaks. | |
| 8 | 34-40 | 39-46 | Fresh gale | Moderate high waves; edges of crests begin to break; foam is blown in steaks. | Very rough, 4.0-6.0 |
| 9 | 41-47 | 47-54 | Strong gale | High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility. | |
| 10 | 48-55 | 55-63 | Whole gale | Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced. | High, 6.0-9.0 |
| 11 | 56-63 | 64-72 | Storm | Exceptionally high waves; sea covered with white foam patches; visibility still more reduced. | Very high, 9.0-13.5 |
| 12<br>13<br>14<br>15<br>16<br>17 | 64-71<br>72-80<br>81-89<br>90-99<br>100-108<br>109-118 | 73-82<br>83-92<br>93-103<br>104-114<br>115-125<br>126-136 | Hurricane | Air filled with foam; sea completely white with driving spray; visibility greatly reduced. Winds of force 12 and above very rarely experienced on land; usually accompanied by widespread damage. | Phenomenal, greater than 13.5 |

DISTRIBUTION LIST
(NOTAL)

SNDL

| | |
|---|---|
| 21A1 | CINCLANTFLT |
| 21A3 | CINCUSNAVEUR |
| 22A1 | COMSECONDFLT |
| 22A3 | COMSIXTHFLT |
| 23B3 | Special Force Commander EUR |
| 24A1 | Naval Air Force Commander LANT |
| 24D1 | Surface Force Commander LANT |
| 24E | Mine Warfare Command |
| 24G1 | Submarine Force Commander LANT |
| 26QQ1 | Special Warfare Group LANT |
| 28A1 | Carrier Group LANT (2) |
| 28B1 | Cruiser-Destroyer Group LANT (2) |
| 28D1 | Destroyer Squadron LANT (2) |
| 28J1 | Service Group and Squadron LANT (2) |
| 28K1 | Submarine Group and Squadron LANT |
| 28L1 | Amphibious Squadron LANT (2) |
| 29A1 | Guided Missile Cruiser LANT |
| 29B1 | Aircraft Carrier LANT |
| 29D1 | Destroyer LANT (DO 931/945 Class) |
| 29E1 | Destroyer LANT (DO 963 Class) |
| 29F1 | Guided Missile Destroyer LANT |
| 29G1 | Guided Missile Frigate (LANT) |
| 29I1 | Frigate LANT (FF 1098) |
| 29J1 | Frigate LANT {FF 1040/1051 Class) |
| 29K1 | Frigate LANT {FF 1052/1077 Class) |
| 29L1 | Frigate LANT (FF 1078/1097 Class) |
| 29N1 | Submarine LANT #SSN} |
| 29Q | Submarine LANT SSBN |
| 29R1 | Battleship Lant (2) |
| 29AA1 | Guided Missile Frigate LANT (FFG 7) |
| 29BB1 | Guided Missile Destroyer (DDG 993) |
| 31A1 | Amphibious Command Ship LANT (2) |
| 31B1 | Amphibious Cargo Ship LANT |
| 31G1 | Amphibious Transport Ship LANT |
| 31H1 | Amphibious Assault Ship LANT (2) |
| 31I1 | Dock Landing Ship LANT |
| 31J1 | Dock Landing Ship LANT |
| 31M1 | Tank Landing Ship LANT |
| 32A1 | Destroyer Tender LANT |
| 32C1 | Ammunition Ship LANT |
| 32G1 | Combat Store Ship LANT |
| 32H1 | Fast Combat Support Ship LANT |
| 32N1 | Oiler LANT |
| 32Q1 | Replenishment Oiler LANT |
| 32S1 | Repair Ship LANT |
| 32X1 | Salvage Ship LANT |

| | |
|---|---|
| 32DD1 | Submarine Tender LANT |
| 32EE1 | Submarine Rescue Ship LANT |
| 32KK | Miscellaneous Command Ship |
| 32QQ1 | Salvage and Rescue Ship LANT |
| 32TT | Auxiliary Aircraft Landing Training Ship |
| 42N1 | Air Anti-Submarine Squadron VS LANT |
| 42P1 | Patrol Wing and Squadron LANT |
| 42BB1 | Helicopter Anti-Submarine Squadron HS LANT |
| 42CC1 | Helicopter Anti-Submarine Squadron Light HSL LANT |
| C40 | Monterey, Naples, Sigonella and Souda Bay only |
| FD2 | Oceanographic Office - NAVOCEANO |
| FD3 | Fleet Numerical Oceanography Center - FLENUMOCEANCEN |
| FD4 | Oceanography Center - NAVEASTOCEANCEN |
| FD5 | Oceanography Command Center - COMNAVOCEANCOM (Rota) |

copy to:

| | |
|---|---|
| 21A2 | CINCPACFLT |
| 22A2 | Fleet Commander PAC |
| 24F | Logistics Command |
| 24H1 | Fleet Training Command LANT |
| 28A2 | Carrier Group PAC (2) |
| 29B2 | Aircraft Carrier PAC (2) |
| 29R2 | Battleships PAC (2) |
| 31A2 | Amphibious Command Ship PAC (2) |
| 31H2 | Amphibious Assault Ship PAC (2) |
| FA2 | Fleet Intelligence Center |
| FC14 | Air Station NAVEUR |
| FD1 | Oceanography Command |
| USDAO | France, Israel, Italy and Spain |

USCINCENT
Attn: Weather Div. (CCJ3-W)
MacDill AFB, FL 33608-7001

Chief of Naval Research
Library, Code 01232L
Ballston Tower #1
800 Quincy St.
Arlington, VA 22217-5000

Office of Naval Research
Code 1122 MM, Marine Meteo.
Arlington, VA 22217-5000

Commandant
Hdq. U.S. Marine Corps
Washington, DC 20380

Officer in Charge
NAVOCEANCOMDET
Naval Educ. & Trng. Center
Newport, RI 02841-5000

Commanding Officer
Naval Research Lab
Attn: Library, Code 2620
Washington, DC 20390

Chairman
Oceanography Dept.
U.S. Naval Academy
Annapolis, MD 21402

NAVPGSCOL
Meteorology Dept. Code 63
Monterey, CA 93943-5000

Naval War College
Attn: Geophys. Officer
NAVOPS Dept.
Newport, RI 02841

COMSPAWARSYSCOM
Code 3213, Navy Dept.
Washington, DC 20363-5100

USAFETAC/TS
Scott AFB, IL 62225

Commanding Officer
USCG Rsch. & Dev. Center
Groton, CT 06340

Director
DTIC, Cameron Station
Alexandria, VA 22314

Commanding Officer
Naval Unit
LNN/STOP 62
Chanute AFB, IL 61868-5000

Commander
Coastal Eng. Rsch. Cen
Kingman Bldg.
Ft. Belvoir, VA 22060

Central Intelligence Agency
Attn: OCR Standard Dist.
Washington, DC 20505

Defense Logistics Studies
Information Exchange
Army Logistics Manage. Cen.
Ft. Lee, VA 23801

Commanding Officer
USCG RESTRACEN
Yorktown, VA 23690

NOAA
Oceanographic Servs. Div.
6010 Executive Blvd.
Rockville, MD 20852

National Climatic Center
Attn: L. Preston D542X2
Federal Bldg. - Library
Asheville, NC 28801

NOAA Rsch. Facilities Center
P.O. Box 520197
Miami, FL 33152

Chief, International Affairs
National Weather Service
8060 13th Street
Silver Spring, MD 20910

Scripps Institution of
Oceanography Library
Documents/Reports Section
La Jolla, CA 92037

Oceanroutes, Inc.
680 W. Maude Ave.
Sunnyvale, CA 94086-3518

Istituto Universitario Navale
Facilta Di Scienze Nautiche
Istituto Di Meteorolgia E
Oceanografia, 80133 Napoli
Via Amm, Acton, 38 Italy

Director, SACLANT ASW
Research Centre
Viale San Bartolomeo, 400
I-19026 La Spezia, Italy

NAVENVPREDRSCHFAC
Attn: D. Perryman,
Wea. Anal. Fcst.
Monterey, CA 93943-5006

Director, Institute of
Physical Oceanography
Haraldsgade 6
2200 Copenhagen N.
Denmark

The British Library
Science Reference Library (A)
25 Southampton Bldgs.
Chancery Lane
London WC2A IAW

Commander in Chief
Attn: Staff Meteorologist &
Oceanography Officer
Northwood, Middlesex HA6 3HP
England

Meteorologie Nationale
SMM/Documentation
2, Avenue Rapp
75340 Paris Cedex 07
France

Meteorologie Nationale
1 Quai Branly
75, Paris (7)
France

Ozeanographische
Forschungsantalt Bundeswehr
Lornsenstrasse 7, Kiel
Federal Republic of Germany

Institut fur Meereskunde Der
Universitat Hamburg
Heimhuderstrasse 71
2000 Hamburg 13
Federal Republic of Germany

Consiglio Nazionale Delle
Ricerche
Istituto Talassografico Di
Trieste, Viale R. Gessi 2
34123 Trieste, Italy

Centro Nazionale Di Meteorolo.
E Climatologia Aeronautica
Piazzale Degli Archivi 34
00144 Roma, Italy

Head, Office of Oceano.
& Limnology
Smithsonian Institution
Washington, DC 20560

Science Applications
Intl. Corp. (SAIC)
205 Montecito Ave.
Monterey, CA 93940

Mr. Dick Gilmore
2145 N. Fairway Ct.
Oak Harbor, WA 98277

Director of Naval Oceano.
& Meteorology
Ministry of Defence
Old War Office Bldq.
London, S.W.1. England

Belgian Air Staff
VS3/CTL-MET
Everestraat 1
1140 Brussels
Belgium

Library, Institute of
Oceanographic Sciences
Attn: Director
Wormley, Godalming
Surry GU8 5UB, England

Service Hydrographique EtT
Oceanographique De La Marine
Establissement Principal
Rue Du Chatellier, B.P. 426
29275 - Brest Cedex, France

Direction De La Meteorologie
Attn: J. Dettwiller, MN/RE
77 Rue De Sevres
92106 Boulogne-Billancourt
Cedex, France

Institut fur Meereskunde
An Der Universitat Kiel
Dusternbrooker Weg 20
23 Kiel
Federal Republic of Germany

Director, Deutsches
Hydrographisches Institut
Tauschstelle, Postfach 220
02000 Hamburg 4
Federal Republic of Germany

Commander, D.W. Taylor
Naval Ship Center
Surface Ship Dynamics Br.
Attn: S. Bales
Bethesda, MD 20084-5000

Director
NAVSURFWEACEN, White Oaks
Navy Science Asst. Program
Silver Spring, MD 20903-5000

3350TH Tech. Trng Group
TTGU/2/STOP 623
Chanute AFB, IL 61868

U.S. Army Research Office
Attn: Geophysics Div.
P.O. Box 12211
Research Triangle Park, NC

Director
Library, Tech. Info. Cen.
Army Eng. Waterways Station
Vicksburg, MS 39180

Director, Env. & Life Sci.
Office of Undersec of Defense
for Rsch. & Env. E&LS
Rm. 3D129, The Pentagon
Washington, DC 20301

Director, Tech. Information
Defense Adv. Rsch. Projects
1400 Wilson Blvd.
Arlington, VA 22209

Chief, Marine Sci. Section
U.S. Coast Guard Academy
New London, CT 06320

Commander
NAVSURFWEACEN, Code R42
Dr. Katz, White Oaks Lab
Silver Spring, MD 20903-5000

Drector, Atlantic Marine
Center, NOAA
Coast & Geodetic Survey,
9 W. York St.
Norfolk, VA 23510

Asst. for Env. Sciences
Asst. SECNAV (R&D)
Room 5E731, The Pentagon
Washington, DC 20350

Office of Naval Research
Code 1122AT, Atmos. Sciences
Arlington, VA 22217-5000

Jefe del, Servicio de Aplica.
Aeronauticas y Maritimas
Instituto Nacional de Meteoro
Calle Universitaria
Apartado 285, 28071 Madrid
Espana SPAIN

The Joint Staff (J-3/ESD)
Environmental Services Div.
Operations Directorate
Washington, DC 20318-3000

Danish Defence Weather Serv.
Chief of Defence
P.O. Box 202
DK-2950 vedbaek DENMARK

Superintendent
Library Reports
U.S. Naval Academy
Annapolis, MD 21402

Director of Research
U.S. Naval Academy
Annapolis, MD 21402

NAVPGSCOL
Attn: Library
Monterey, CA 93943-5002

Commander
Naval Safety Center
Naval Air Station
Norfolk, VA 23511

Federal Coord. for Meteoro.
Servs. & Sup. Rsch. (OFCM)
11426 Rockville Pike, Rm 300
Rockville, MD 20852

Director
National Oceano. Data Center
E/OC23, NOAA
Washington, DC 20235